Women in physics
The last thirty years
A personal perspective

ICTP, Trieste 2014

My experience in Italy

In Southern Italy, in the 50's and 60's:

- In the space of a decade or two, women went from preparing hope chests to pursuing education and professional training.
- Women needed to work, and they looked for jobs compatible with family, such as jobs in education. To teach physics in school, you needed to get a college degree in physics. The required high school math and science courses prepared them to attend college in math or physics.
- Many women went into math and science degrees, so to be able to find teaching jobs. Many stayed for a PhD.
- Being a physicist was not exceptional.

Situation in the USA in the 70'-80's

- In the USA women in math and physics were far fewer than in Europe and Italy both at the Professional level (researchers, professors) and at college level (undergraduate students).

- Why were not girls in the undergraduate physics classes?

First bottleneck effect

- In the USA, girls (and boys) opted out of math and science in HS.
- HS math and science requirements very weak
- HS math and science courses very intense and challenging
- Layer-cake approach
- Peer pressure
- After high school, girls were not ready for the challenging college courses, and they immediately opted out.

The role of the educational system. Differences between USA and Italy

- No bottleneck effect in HS. Math and science required every year.
- Courses more systematic and accessible. Everybody is expect to know basics.
- Everybody has enough background to enroll in math and science courses in college.
- No distinction between training for teachers and training for scientists at the undergraduate level. Hence, good teachers, and many potential scientists.

- To teach math or physics in Italy today you need
- Laurea with specialization in math (5 yrs)
- Corso di tirocinio (pratico e teorico)
- National competition (concorso)
- In the US you attend a school of education
- Hired at the local level

The second bottleneck effect

- After a PhD, the scientific career starts and the reproductive clock starts clicking.
- Difficulties with raising a family and combining work with family duties.
- In Europe, low-paid long-term research position available.
- In Europe women could count on their extended family support.
- More child care available, more daycare
- No daycares in the USA, UNOW started a few in the 70-80's

The second bottleneck effect

- Women leave science and engineering careers twice as frequently as man (1996)
- Women salaries in science and engineering lag behind men's by 12-15 percent. (1995)
- But the situation much better in the life sciences, also in terms of retention in academia and visibility in the field. In physics, the numbers are higher for women in astrophysics and cosmology.

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OPINION

ON MATHEMATICS AND SCIENCE EDUCATION IN THE US AND EUROPE

Chiara R. Nappi

In the last few years the deficiencies of US education in mathematics and science have come into clearer focus. In high school, US students lag behind students in most European (as well as some Asian) countries in terms of math and science performance. In college, six out of ten students who enroll with the intent of pursuing a scientific career end up switching to a non-science major. At the PhD level, half of the graduate students in math and science are foreigners.

This situation has raised much concern. It is felt by many national leaders that unless things change, the US's economic standards will follow those of the test scores. A shortage of scientists and engineers in the coming decade is already predicted, and it is argued by many that one way the US can meet these future demands is to get more women and minorities into science.

The problems experienced by women and minorities in math and science are also well known. Girls consistently score between 40 and 50 points lower than boys on the math section of the SAT test. Blacks account for 2% of all employed scientists and engineers, while they represent 10% of the US work force. Women account for 15% of scientists and engineers (up from 9% in 1976, mostly due to the influx of foreign female PhDs), but they are 44% of all employees.

There is, however, a point that has not been made: The participation of women in math and science seems to be worse in the United States than it is in Europe. There, the difference between boys' and girls' performances in math and science in high school final exams is less dramatic.[1] In European colleges, enrollment of men and women in math and science courses is more balanced. And, although most women science majors opt to become math or science teachers in middle or high school, the percentage of women in research and academia—about 20%—is higher than it is in the United States.[2]

The reasons behind these phenomena are many and complex. It is, however, enlightening to point out some of the differences between the educational systems in the US and Europe that may explain these differences. Indeed, comparing methods can be more informative than just comparing test scores.

First of all, up to middle school, the study of math and science (especially math) proceeds at a much slower pace in the US than in Europe. For instance, the first two years of math—usually called "algebra 1" and "geometry"—taken by the average American high school student mostly cover topics that European children learn in middle school. Because a majority of American high schools only require one or two years of math to graduate, many students never take a math course beyond algebra 1 or geometry. In other words, a student can graduate from an American high school knowing only as much math as a middle school student in Europe.

A consequence of this approach is that the amount of mathematics that foreign high school students learn over four or five years is concentrated in the last two years of high school in the US. These math courses are therefore necessarily very fast-paced and intensive. Moreover, they are usually elective, or optional, courses. It is not surprising that a good 50% of American students give up and content themselves with only fulfilling the minimal requirements. By doing so, however, these students, typically aged only 15, have virtually precluded themselves from pursuing math or science in college. Indeed, to be a science or math major in college, one must at least study trigonometry (and maybe precalculus), usually a fourth-year math course in high school. It is this lack of a good high school background that is responsible for the 60% of US college science students who switch to non-science majors.

There is no doubt that such a system places American students at a disadvantage with respect to students abroad. The approach in Europe is more systematic and steady in math and science, as in all other subjects: Students start studying math and science at an earlier age and proceed through high school at a more relaxed pace. In the lower grades, while basic math and problem-solving skills are mastered, concepts of higher-order mathematics are also introduced. In high school, there are no crash courses. For example, most American high school students study algebra intensively for a whole year, with daily classes on the subject, only to drop it the following year to concentrate on another subject, such as geometry, for another intense full year. But in Europe these subjects are studied in parallel over several years. Likewise, the physics that American students are supposed to learn in a year is spread over three or four years in Europe. Concepts in math and science need to be assimilated, and that takes time. European high school students study physics, chemistry, biology and mathematics every year. The amount that they study varies from one type of high school to another, but they all must take these subjects every year.

The point I want to make is the following: *If courses are unnecessarily tough, and morever optional, students do tend to opt out.* The teenage years are particularly critical. Boys and girls undergo so many physical and emotional changes that it is unwise to place too much pressure on them just then. It is the time when gender roles and stereotypes really sink in. Especially in the United States, there is a great deal of pressure on girls to concentrate on being socially successful. Morever, stereotypes can have an

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From 1980 outreach efforts in the USA to address the first bottleneck effect

AAAS: “we do not require, we motivate and encourage”

AWIS

An infinite number of programs to increase the numbers of women in science/math/engineering. Many resources devoted to this issue.

WISE Women in Science and Engineering: outreach, recruitment and detention

IAS program for women in mathematics

Almost mandatory to do outreach if one gets an NSF grant

Trouble with implementing Common Core Standards

Addressing the second bottleneck effect

Parenting leaves and workload relief:

- Paid temporary disability from 3 weeks before to 6-10 week after.
- One semester relief from teaching duties.
- One year automatic extension of the tenure clock.
- Up to one year of unpaid parenting leave.

The current situation in grade school

AAUW report 2010: “today girls are doing as well as boys in math.’’ In high school, not only are girls earning math and science credits at the same rate as boys, but their grades tend to be slightly higher. Since 1980, the ratio of boys to girls among students scoring above 700 on the math SAT has dwindled from 13:1 to 3:1.

(Totally in line with what I had observed in Italy for decades)

Recent example from abroad: 6/9 of the top math college students honored by the Irish Royal society are girls.

Colleges/universities

- Nationwide women are 20% of the undergraduate majors, 20% of graduate students, and 14% percent of professors. At PU the fractions are even smaller for graduate students and faculty. In the US things are changing; the head of the NSF is a woman and the next president of the APS is a woman.

2010 report, "Why So Few?," of the American Association of University Women

- Only 14% of physics PhD's are women, and women make up for 12% of applicants for tenure track positions

When women . . . apply for STEM faculty positions at major research universities ``they are *more* likely than men to be hired.''

In 2006, women made up a little less than 14 percent of the tenured faculty in the physical sciences in four-year colleges and universities.

It is not a race, but

- Still differences with Europe:
- At CERN, 30% of the researchers are women (mostly European), with a majority of them (32%) from Italy followed by France at a distant 8%.
- Numerous Italian women hold faculty jobs in math and physics in US universities.

The third bottleneck effect

Success? Recognitions?

January 2001, California Institute of Technology; MIT; Harvard, Princeton, Stanford, and Yale Universities; and the Universities of Michigan, Pennsylvania, and California, Berkeley: institutional barriers have prevented women scientists and engineers from having a level playing field in their professions.

A serious problem in Europe too. Two body problem. But advances are on the way, and here the USA take the lead…

Conclusions?

- The US has invested an enormous amount of resources in outreach, and finally caught up with

``family rights”.

- One does not need to have the US resources to address this issue. Other countries are still doing better than the US.
- But of course much remains to be done everywhere: visibility, glass ceiling, etc.: The third bottleneck effect.